

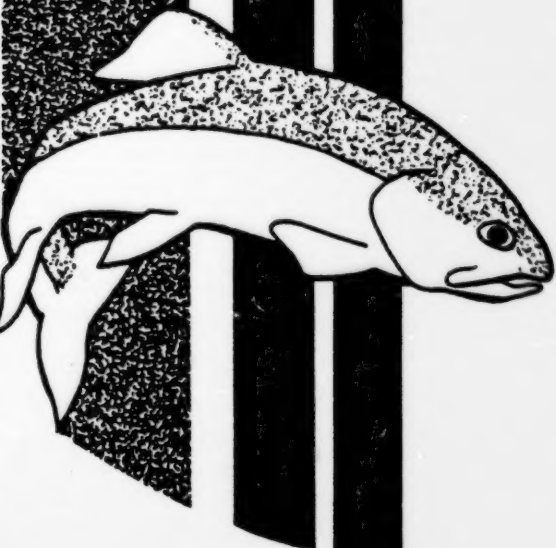
Detoxification and Decontamination of Waters Following Chemical Rehabilitation with Noxfish

by

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ABSTRACT

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Water samples were collected from three lakes which were chemically rehabilitated in 1986 by the Province of British Columbia, Ministry of Environment, Recreational Fisheries Branch. Samples were analyzed for rotenone and the Noxfish diluent, to determine both persistence and rate of detoxification. Results indicated that both rotenone and the Noxfish diluent were essentially nondetectable in water samples taken 7 months after fall treatments. The rates at which rotenone became nondetectable ranged from 17 to at least 77 days. The Noxfish diluent reappeared after some period of absence in 2 lakes, including detection the following spring. It was recommended that routine water sampling occur where waters are used for domestic purposes, and that monitoring programs similar to this be continued and expanded to cover other piscicide formulations as used. Further programs to determine inert ingredient dissipation rates, pathways within lake systems for uptake and release of inert ingredients, and toxicity of inert ingredients to nontarget organisms are also required.

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INTRODUCTION

Rotenone, an organic piscicide, has been used in fisheries management programs in British Columbia since 1947 (Tredger 1978). Recently, the Fisheries program has become increasingly concerned about quantifying the effects and fate of chemicals used in lake rehabilitation programs. Broadly based research has demonstrated the environmental and human safety aspects of rotenone when used as a piscicide in fisheries management (Sousa *et al.* 1987). The rate of natural degradation of rotenone has been reported in several studies (Post 1958, Engstrom-Heg and Colesante 1979, Gilderhus *et al.* 1986, 1988). Little research has been directed at inert ingredients: the diluents, emulsifiers, solvents, wetting agents and carriers which comprise up to 90% of some liquid rotenone formulations currently in use. Contamination of water supplies by inert ingredients following treatment with some formulations has been reported (Bonn and Holbert, 1961). In B.C. lakes, reports of a "diesel taste" in fish have been received as much as 7 years following some piscicide treatments.

This report describes the detoxification and decontamination of waters treated with Noxfish, a 5% liquid formulation produced by Roussel Bio Corporation. Water samples were collected from three lakes which were chemically rehabilitated in 1986 by the Province of B.C., Ministry of Environment, Recreational Fisheries Branch. The samples were analyzed for rotenone and the Noxfish diluent, to determine both persistence and rate of detoxification.

METHODS

Three lakes chemically rehabilitated in the fall of 1986 as part of regional fisheries management programs were included in this study: Dunalter, Summit and Lower Second lakes (Figure 1). Some comparative characteristics are given in Table 1. All three were treated with Noxfish, at a concentration of 1.5 mg/l (0.075 mg rotenone/l). Water samples were collected at one station in each lake. Sample dates varied between lakes; however, both rotenone and Noxfish diluent were monitored until nondetectable. Samples were collected in accordance with standard procedures of the Ministry of Environment's Environmental Laboratory. Analysis was conducted by the Environmental Laboratory, using high performance liquid chromatography to determine rotenone and the Noxfish diluent.

RESULTS

Concentrations of rotenone and the Noxfish diluent in water samples from Dunalter, Summit and Lower Second lakes are summarized in Tables 2 through 4.

In Dunalter Lake (Table 2), rotenone was persistent at relatively high concentrations (0.023 to 0.043 mg/l) in the samples until at least December 16, 1986 (61 days). By the following spring, (May 19, 1987; 215 days



Figure 1. Location of Dunalter, Summit and Lower Second lakes.

Table 1. Some physical and morphometric characteristics of Dunalter, Summit and Lower Second lakes.

	Dunalter	Summit	Lower Second
Surface Area (ha)	22.5	150.4	5.3
Mean Depth (m)	5.5	4.4	3.8
Maximum Depth (m)	18.0	17.0	9.5
pH	6.5	7.8	8.9
TDS	44 - 56	86 - 104	189
Flushing Rate on treatment date (yrs ⁻¹):	0	0.73	0
Water Temperature on treatment date (°C):			
surface	10.5	11.0	11.5
bottom	4.9	8.0	9.0
Dissolved Oxygen on treatment date (mg/l):			
surface	9.4	9.2	6.1
bottom	0.5	4.0	1.2
Treatment Date	Oct 16, 1986	Sept 30, 1986	Sept 30, 1986

Table 2. Concentration (mg/l) of rotenone and Noxfish diluent in Dunalter Lake water samples. Treatment date October 15 - 16, 1986, at 1.5 mg Noxfish/l (0.075 mg rotenone/l, 1.28 mg Noxfish diluent/l).

Date	Days After Treatment	Sample Depth (m)		
		0	8	17
Rotenone				
Oct 16, 1986	0			
Oct 21, 1986	5	0.049	0.010	0.007
Nov 4, 1986	19	0.056	0.043	0.011
Dec 16, 1986	61	0.043	0.035	0.023
May 19, 1987	215	<0.005	<0.005	<0.005
Noxfish Diluent				
Oct 16, 1986	0			
Oct 21, 1986	5	0.04	0.04	0.09
Nov 4, 1986	19	0.17	0.36	0.06
Dec 16, 1986	61	<0.01	<0.01	<0.01
May 19, 1987	215	<0.01	<0.01	0.02

rotenone was nondetectable at all depths. Rotenone concentrations were lower at the deeper stations on all dates, and particularly within 19 days of the treatment. The Noxfish diluent was nondetectable by December 16, 1986 (61 days) at all stations. Sample concentrations were highest on the second sample date (Nov. 4, 1986; 19 days). Diluent was not detected on December 16, 1986 (61 days), while the following spring (May 19, 1987; 215 days) a low concentration (0.02 mg/l) was detected at the 17 m station.

In Lower Second Lake (Table 3), rotenone was nondetectable in all samples taken, beginning October 17, 1986, 17 days after treatment. Initially the Noxfish diluent was also nondetectable. However, by November 5, 1986 (36 days) and continuing through March 13, 1987 (163 days), the diluent was detected at up to 0.17 mg/l. By April 24, 1987 (205 days) the diluent was again nondetectable.

Table 3. Concentration (mg/l) of rotenone and Noxfish diluent in Lower Second Lake water samples. Treatment date Sept. 30, 1986, at 1.5 mg Noxfish/l (0.075 mg rotenone/l, 1.28 mg Noxfish diluent/l).

Date	Days After Treatment	Sample Depth (m)	
		0	17
Rotenone			
Sept 30, 1986	0		
Oct 17, 1986	17	<0.005	<0.005
Nov 5, 1986	36	<0.005	<0.005
Nov 24, 1986	55	<0.005	<0.005
Dec 10, 1986	71	<0.005	<0.005
Jan 16, 1987	108	<0.005	<0.005
Feb 17, 1987	139	<0.005	<0.005
Mar 13, 1987	163	<0.005	<0.005
Apr 24, 1987	205	<0.005	<0.005
May 20, 1987	231	<0.005	<0.005
Noxfish Diluent			
Sept 30, 1986	0		
Oct 17, 1986	17	<0.01	<0.01
Nov 5, 1986	36	0.03	<0.01
Nov 24, 1986	55	0.17	0.10
Dec 10, 1986	71	0.15	0.14
Jan 16, 1987	108	0.11	0.07
Feb 17, 1987	139	0.06	0.03
Mar 13, 1987	163	0.01	0.01
Apr 24, 1987	205	<0.01	<0.01
May 20, 1987	231	<0.01	<0.01

In Summit Lake (Table 4), rotenone concentrations 13 days after treatment (Oct. 13, 1986) remained high (0.047 to 0.048 mg/l) in the 0 and 7 m depths, and were nondetectable at the 14 m station. One week later (Oct. 20, 1986; 20 days), concentrations were reduced (0.010 to 0.016 mg/l) at the 0 and 7 m stations, and remained nondetectable at the 14 m station. One further week later (Oct. 27, 1986; 27 days), concentrations were uniform throughout the water column (0.014 to 0.015 mg/l). Rotenone was nondetectable at all stations in the spring (April 8, 1987; 190 days).

Table 4. Concentration (mg/l) of rotenone and Noxfish diluent in Summit Lake water samples. Treatment date Sept. 30, 1986, at 1.5 mg Noxfish/l (0.075 mg rotenone/l, 1.28 mg Noxfish diluent/l).

Date	Days After Treatment	Sample Depth (m)		
		0	7	14
Rotenone				
Sept 30, 1986	0			
Oct 13, 1986	13	0.048	0.047	<0.005
Oct 20, 1986	20	0.010	0.016	<0.005
Oct 27, 1986	27	0.014	0.015	0.014
Apr 8, 1987	190	<0.005	<0.005	<0.005
Noxfish Diluent				
Sept 30, 1986	0			
Oct 13, 1986	13	0.11	0.15	<0.01
Oct 20, 1986	20	0.02	0.05	<0.01
Oct 27, 1986	27	<0.01	<0.01	<0.01
Apr 8, 1987	215	<0.01	<0.01	<0.01

The Noxfish diluent was detected at the 0 and 7 m depths in Summit Lake 13 and 20 days after treatment (Oct. 13 and 20, 1986). No diluent was detected at the 14 m station on any date. No diluent was detected on Oct. 27, 1986 (27 days) or in the spring (April 8, 1986; 190 days).

Sampling in the Summit Lake outlet stream was conducted at three locations: the lake outlet, the barrier site (700 m downstream of the lake), and 12 km downstream of the lake. At the lake outlet rotenone was not detected on the 2 dates sampled. At the barrier site rotenone was present 20 and 27 days after treatment (Oct. 20 and 27, 1986), but was nondetectable by spring (April 8, 1987; 190 days). Rotenone was nondetectable 12 km downstream of the lake on all sample dates. The Noxfish diluent was not detected at any outlet station over the entire sampling period.

DISCUSSION

For the three lakes monitored, both rotenone and the Noxfish diluent were essentially nondetectable in water samples taken approximately 7 months after fall treatments. However, behavior of rotenone and the Noxfish diluent varied between the lakes. Rotenone degraded relatively quickly in Lower

Second Lake, as it was not detected in samples collected beginning 17 days after treatment. Rotenone was present for at least 27 days following treatment in Summit Lake. In Dunalter Lake, rotenone was found for at least 61 days, and was present in higher concentrations than in Summit Lake. The persistence of rotenone in terms of days or months in Summit and Dunalter Lakes cannot be determined given the sampling schedule conducted.

Longer persistence of rotenone in Dunalter Lake in comparison to Lower Second Lake can be explained in part by colder water temperature and greater lake depth. Persistence of rotenone is mainly a function of light intensity and temperature (Engstrom-Heg 1987), although other factors are known to have some effect. The findings of Post (1958) and Engstrom-Heg and Colesante (1979) indicate degradation occurs at a constant negative exponential rate, with a rate constant varying directly with temperature. Gilderhus et al. (1988) found the half life of rotenone was 10.3 days in cold water (0 to 5°C) and 0.94 days in warm water (23 to 27 °C) ponds, and persistence of a 0.25 mg rotenone/l treatment of 46 days in the coldwater and 6 days in the warmwater pond. At treatment time, water temperature in Dunalter Lake ranged from 10.5 to 4.9°C, while Lower Second Lake had a temperature range of 11.5 to 9°C.

Engstrom-Heg and Colesante (1979) indicate that light intensity increases degradation rate, and suggested that faster degradation rates reported in Post (1958) were due to greater light intensity. Dunalter Lake had mean depth of 5.5 m and maximum depth 18 m, while Lower Second Lake had mean depth of 3.8 m and maximum depth of 9.5 m. As light intensity is known to decrease with depth, longer persistence in Dunalter Lake is consistent with the morphometry of the systems.

The Noxfish diluent behaved differently than rotenone. The diluent disappeared relatively quickly in Dunalter and Summit lakes, while a relatively long persistence following initial absence was found in Lower Second Lake. A small concentration of diluent was detected at ice-off the following spring in Dunalter Lake after a period of absence. The reasons for re-appearance of the diluent are unclear, but may relate to uptake and release by bottom sediments (Gilderhus et al. 1988, Dawson et al. 1986) and macrophytes (Gilderhus 1982).

RECOMMENDATIONS

Rapid decontamination and detoxification by piscicides used in the provincial lake rehabilitation program are very important considerations where domestic water use is involved. In B.C., permit conditions governing the use of registered piscicides state that alternate water supplies shall be provided to all domestic water users from the time of treatment until the rotenone is found to be nondetectable by the Ministry's Environmental Laboratory. The Pesticide Control Branch has adopted "nondetectable" as the acceptable standard for organic pesticides that have not been specifically identified in the Canadian Drinking Water Standards. Detectable limits have been set by the Environmental Laboratory as 0.005 mg/l for rotenone and 0.01 mg/l for the Noxfish diluent.

Rotenone may not degrade for long periods of time in cold, deep waters. Formulae for predicting the persistence of rotenone developed by Engstrom-Heg and Colesante (1979) indicate persistence of 0.025 mg rotenone/l is possible for up to 405 days at 4°C. They do indicate this would be rare in practical terms because of dilution (both inflows and mixing with surface waters) and adsorption by sediments. Where water is used for domestic purposes, regular water sampling should be conducted to ensure nondetectable levels are present before alternate supplies are terminated. The same should apply to outlet streams relative to downstream users. In general, waters are fit for human use by the following spring. However, the detection of diluent after some period of absence is of concern. In planning a chemical lake rehabilitation, budget must reflect the need for water sampling and supply of alternate domestic water sources to cover the expected length of persistence. The sampling frequency in two of three lakes studied were inadequate to determine when rotenone was nondetectable. Sampling should be extended throughout the winter in fall treatments in the future. Swift detoxification in warm or shallow waters might favor summer treatments in some instances.

Where water use is of concern, rotenone powder might be the best alternative. Rotenone itself has been well researched, and found environmentally safe when used as directed. Inert ingredients present in the liquid formulations have not been subject to the same level of analysis in terms of their use in piscicide formulations. While the inert ingredients are safe, and are cleared by the U.S. Environmental Protection Agency (California Dept. of Fish and Game, 1985), we cannot respond to questions of its environmental safety as well as we can for rotenone at this time.

Further research into the environmental safety of inert ingredients is required, through literature, field and laboratory research. As quantity and formulations of inert ingredients are different in various rotenone-based piscicides, lake monitoring programs similar to this should be continued. Such sampling should be conducted for all projects where domestic water use is involved, and for all projects where formulations other than Noxfish are used. Sampling should be expanded to examine the pathways for uptake and release of the diluents by macrophytes and bottom sediments. Controlled laboratory monitoring of diluent dissipation rates, and bioassays to determine the toxicity of diluents to nontarget organisms are also required.

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